2006 Hanford Reach Agreement Spawning Experiment

Final Study Plan

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1.0 Introduction

The following is the final study plan by the Public Utility District of Grant County (Grant PUD) for the 2006 Hanford Reach Agreement Spawning Experiment. As per the Hanford Reach Fall Chinook Protection Program (HRFCPP), an evaluation of discharge alternatives was conducted in 2005. Normal load following was evaluated, which was a reversal of traditional Reverse Load Factor operations (RLF) under the Vernita Bar Agreement. RLF is defined as higher flows at night with lower flows during the day (Lukas 2003). Using hydroacoustic telemetry, fall Chinook salmon *(Oncorhynchus tshawytscha)* were captured, tagged, and released to examine spawning behavior and changing flow conditions. Underwater video and DIDSON technology were also used to measure redd digging rates which was used to compare daytime and nighttime spawning activity. As per the HRFCPP, Grant PUD will continue experimental testing during the 2006 fall Chinook spawning period. This study plan was developed after reviewing the 2005 results, and discussions with mid-Columbia operators, agencies, and tribes. The objective of this project is to better balance resources by increasing river operation flexibility while reducing fall Chinook spawning at higher elevations on Vernita Bar. One method for testing the successfulness of this experiment is to determine the number of redds constructed above the 65 kcfs elevation throughout the spawning period. As during previous years, Vernita Bar redd surveys will be conducted by the Monitoring Team (Lukas 2003).

There will be four hypotheses tested during this project and specific statistical analyses for testing these hypotheses will be presented in different sections throughout the study plan. The hypotheses are: 1. Adult fish activity (movement of fish positions determined by hydroacoustic tracking) during peak discharge is greater than fish activity during non-peak discharge. 2. Fish position on Vernita Bar is higher during peak flow than during non-peak flow. 3. There is an inverse relationship between increasing water velocity and redd production. 4. The number of redds constructed above 65 kcfs elevation in 2006 will be less than or equal to the mean number of redds constructed above 65kcfs elevation under RLF operation (calculated from annual Vernita Bar redd surveys).

2.0 2005 Results

One objective of the study during 2005 was to determine if any nighttime spawning activity occurred, and compare nighttime spawning frequencies with daytime spawning frequencies (expressed in digs per minute). Fall Chinook dug redds both day and night (Figure 1.) but overall, there was a higher rate during the day (0.314) than at night (0.172). The mean spawning rate was greater during daylight hours but the difference between daytime and nighttime hours was not statistically significant (P=0.1498) (Duvall 2006).

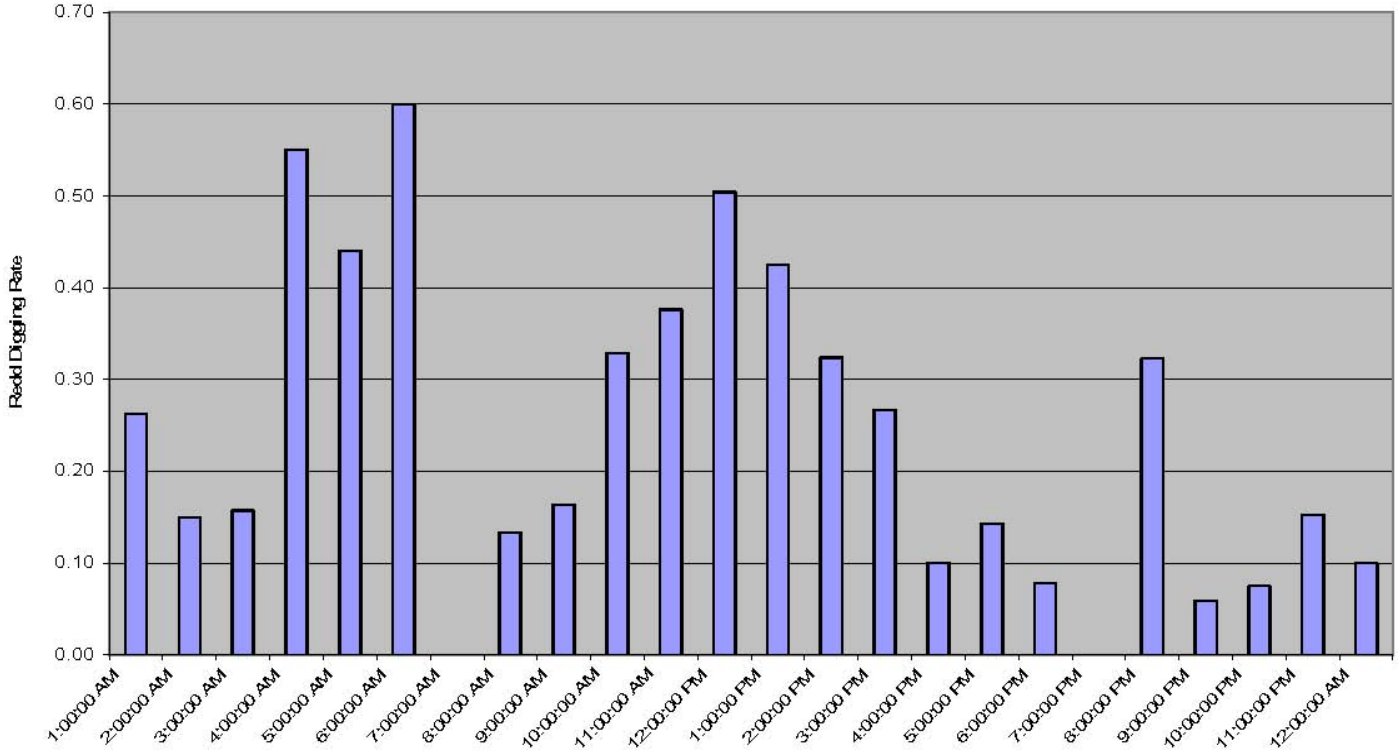


Figure 1. Mean number of redd digs per minute reported by hour. Data were compiled from 15 minute samples systematically selected from all recorded DIDSON files. Technical difficulties resulted in no data collection during 0700 hours.

Redd counts were conducted on Vernita Bar by the Monitoring Team in 2005, per language within the HRFCPP. The November 6th redd survey found a total of 31 redds above 65 kcfs elevation, which met the maximum number of redds above that elevation allowed for the experiment. The experimental flow regime was discontinued the following Monday and RLF operation resumed, while hydroacoustic, DIDSON, and video data collection continued. The 31 redds counted on

November 6th represented 32% of the total redds observed above 65 kcfs elevation (Table 1). Redds counted after experiment flows were discontinued represented 59% and 9% of the 98 total redds constructed above 65 kcfs on Vernita Bar.

Table 1. Official counts taken from Vernita Bar redd surveys in 2005

	Flow intervals (kcfs)						
DATE	36 – 50	50 – 55	55 – 60	60 – 65	65 – 70	70+	TOTAL
Oct. 9	0	0	0	0	0	0	0
Oct. 16	0	0	0	0	0	0	0
Oct. 23	1	0	0	0	0	0	1
Oct. 30	57	8	3	0	1	1	70
Nov. 6	--	58	39	22	10	21	150
Nov. 13	--	145	97	80	39	50	411
Nov. 20	--	--	--	74	38	60	172

Another objective was to measure redd site fidelity of Chinook by evaluating movements in relation to changes in river discharge or flow. Although the quality and quantity of tracking data collected was not sufficient enough to fully test this hypothesis, the following tendencies were found:

1. There tends to be more movement towards the bar when flows increase than when they decrease.
2. There tends to be more fish positioned closer to the bar when flows are high than when flows are low.

The tracking data also suggested that individual responses differed to changes in discharge. Data from tag code 3070 showed the fish elected to remain in one general location (possible redd) over a nineteen day period. During that time, the fish was exposed to a wide range of fluctuating discharge. In another example on November 11th the river flow decreased from 156.8 kcfs to 103.7 kcfs in one hour. During this 53.1 kcfs decrease in discharge, the fish with tag code 3440 moved approximately 4 m towards Vernita Bar, while the fish with tag code 3050 shifted approximately 3 m away from the bar.

3.0 Discussion

Results from the DIDSON data provide a clear picture of spawning activity and digging rates, while providing data that suggests extensive nighttime spawning behavior. Grant PUD is confident with the evaluation and results of day versus night spawning activity and feels it is not necessary to further evaluate this objective. Although the fish with tag code 3070 suggested some evidence of redd site fidelity, tracking data were insufficient to fully evaluate site fidelity and responses to changes in discharge. Therefore in order to continue the 2005 objective of evaluating redd site selection and fidelity, Grant PUD proposes to expand the experiment through increased numbers of hydrophones, increased tag numbers, and improved capture and tagging methods and locations.

Grant PUD proposes to modify river operations during the 2006 experiment. The alternative flow experiment ended premature in 2005 because 31 redds were counted above the 65 kcfs elevation (criteria of HRFCPP). It appears discharge may have been kept high for too long each day (due in part to river conditions during 2005). Therefore, in 2006 Grant PUD will attempt to increase peak heights and decrease peak durations.

The percentage of redds that were constructed above the 65 kcfs elevation were higher after the experiment was discontinued than during the experiment. Questions to consider after reviewing the results of the 2005 Vernita Bar redd surveys are; did the flow/discharge experiment cause the fish to select locations higher on Vernita Bar in preparation for spawning? Would the fish have elected to spawn there under normal RLF conditions, or was it was it based on higher spawning activity because of an increase in spawner abundance later in the season? Also the apparent inconsistency in behavior of the two fish (examples from the previous section) could be the result of an inadequate data set or it could be related to a biological cue exhibited by each fish.

4.0 2006 Methods

4.1 Fish Capture

The objective is to capture, examine, select, and tag enough fish throughout the spawning period to provide sufficient statistical power to test the hypotheses. The fish should be in pre-spawn condition, captured prior to selecting a location to begin redd construction. One potential reason for

limited tracking data in 2005 was the capture location of the fish that were tagged. Rather than use a side channel exposed during low flow, Grant PUD proposes using a tangle net fished adjacent to Vernita Bar, immediately downstream of the hydroacoustic array. This will be the primary capture method and location. Locations further downstream have been suggested and will be considered if an adequate tagging station can be established. Taking these measures should increase the number of tagged fish that that will remain on Vernita Bar to spawn.

A tangle net measuring approximately 100 m in length and 5 m in depth with a mesh size of approximately 12 cm will be used. Nets similar to this have been successfully used in the lower Columbia River during spring Chinook harvest seasons (Vander Haegen 2004). The Washington Department of Fish and Wildlife has also used them for research purposes (Ashbrook et al. 2005). Tangle nets allow the release of unwanted bycatch much easier than traditional gill nets. The use of beach seines in 2005 resulted in minimal bycatch with no bull trout or summer steelhead captured. Based on results in 2005 and the time of year, bycatch is expected to be minimal with tangle nets as well.

4.2 Fish Tagging

In order to increase our understanding of fish movement and behavior in relation to changes in river flow, Grant PUD proposes similar data collection methods but different river operations. Seventy-five fish will be selected to receive tags in 2006. Tags will be Hydroacoustic Technology, Inc. (HTI) model 795F (9 mm x 21 mm and weigh 2.2 g in air). Tagging methods will be similar to those used last year (Duvall 2005) with the exception of using smaller tags in order to reduce potential impacts to behavior of the fish. Since a recreational fishery will run concurrent for a portion of the study, warning signs will be posted at high-use boat ramps for public notification of the experiment, indicating marked fish should be released. The hydrophone array will be in a similar location as 2005; however, the number of antennas will be increased from eight to 15. There will be three different transects of five hydrophones each, distributed at different elevations on Vernita Bar. The hydrophones will be approximately 75 m apart, thereby increasing the detection range from 36,000 m^2 in 2005 to 84,375 m^2 in 2006. This modification should increase the amount of tracking data collected. The hydrophones will be connected to one HTI 290 receiver

on the left-bank shoreline of Vernita Bar. Buoys will be attached to the equipment to aid in retrieval.

4.3 Tracking and Monitoring

Grant PUD will conduct boat-based mobile tracking from the Vernita Bridge to PRD to help identify tagged fish that were not detected within the hydrophone array. Redd counts on Vernita Bar will be conducted by the Monitoring Team, per the HRFCPP. The survey area will be at the same location where previous redd counts have occurred. To reduce the chance of acoustic tag data loss, site visits will be done daily by Grant PUD staff to ensure the equipment is running properly. Finally, per the HRFCPP, up to five aerial flights will be conducted on Vernita Bar and throughout the Hanford Reach to monitor redd distribution.

4.4 River Operation

The objective for river operation during this experiment is to provide conditions for maximum spawning in areas where protection can be maintained during Incubation and Emergence Periods (Lukas 2003). To achieve this objective, Grant PUD is proposing to provide consecutive hours of low, flat, flow (base flow approximately 55-60 kcfs for 16-20 hours) from PRD. Providing base flow for a majority of the day requires one or two short periods of relatively high discharge. Depending upon river conditions this fall, four different operational alternatives may be used during the experiment. Mean daily inflows to PRD will be projected each week and will dictate which alternative will be used during that week. However, conditions may require modifications of operations on a daily basis. Real-time conditions will dictate exact river operations but they will occur within following the general guidelines, hereafter called River Operational Alternatives:

1. PRD mean daily discharge of less than 70 kcfs - One single peak of water (of up to 190 kcfs) each day starting around the 0600 hour. The peak will last approximately 2.5 hours after which flows will be rapidly reduced (to 36 kcfs) until the United States Geological Survey (USGS) gauging station downstream of PRD measures approximately 55 kcfs. The river will then be stabilized until the peak on the following day (Figure 2).

2. PRD mean daily discharge of 70 to 85 kcfs - Two peaks (of up to 190 kcfs) each day with one occurring during morning hours and an additional afternoon spike. The peaks will last approximately 2.5 hours after which flows will be rapidly reduced (to 36 kcfs) until the USGS gauging station downstream of PRD measures approximately 60 kcfs. The river will then be stabilized until the next peak (Figure 2).

3. PRD mean daily discharge of 85 to 105 kcfs - Two peaks (of up to 190 kcfs) each day with one occurring during morning hours and an additional afternoon peak. The peaks will last approximately 2.5 hours after which flows will be rapidly reduced (to 36 kcfs) until the USGS gauging station downstream of PRD measures approximately 65 kcfs. River conditions will dictate how much the duration of each peak is increased. Priority will be to extend the duration of the afternoon peak. The river will then be stabilized until the next peak (Figure 2).

4. PRD mean daily discharge of greater than 105 kcfs - Should the three previous options fail, or discharge is expected to exceed 105 kcfs for an extended duration, the experiment would be discontinued, reverting back to RLF (Figure 2). If 31 redds are counted above 65 kcfs (criteria of the HRFCPP), Alternatives 1, 2, and 3 would be discontinued and Alternative 4 (RLF) would be used for the remainder of the spawning season.

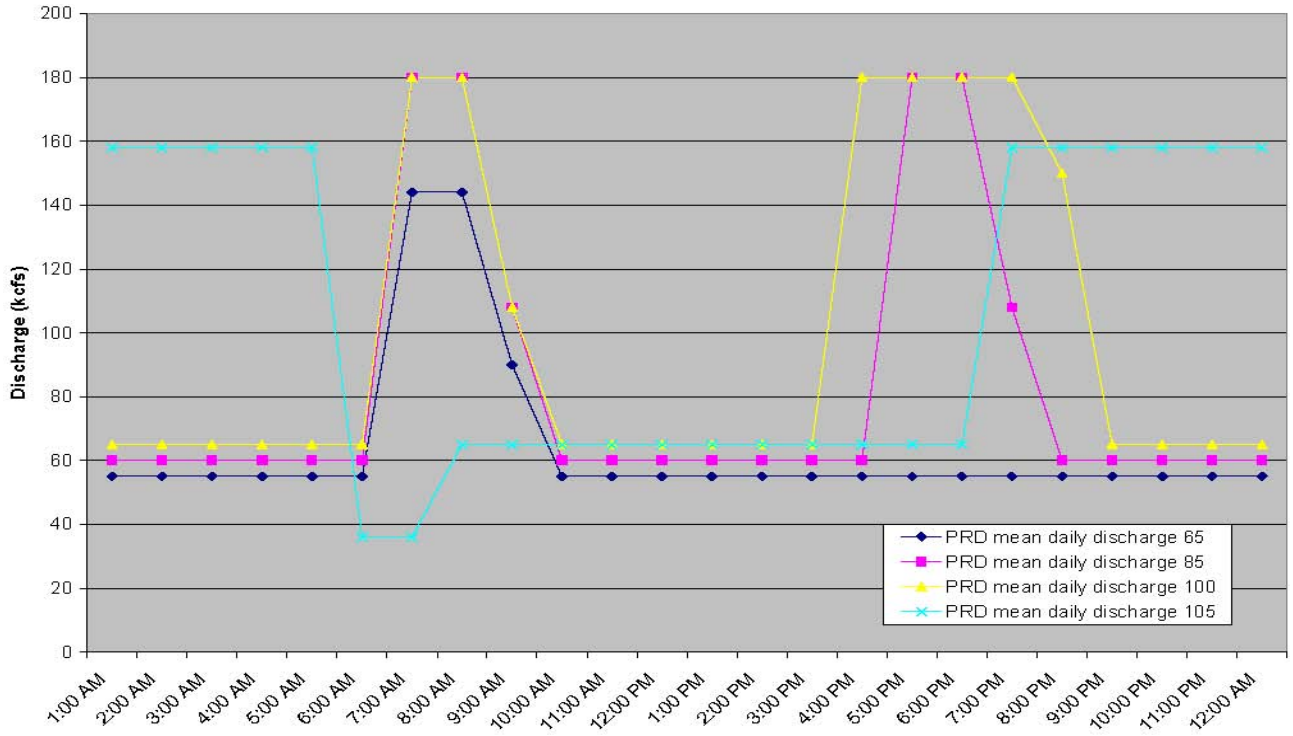


Figure 2. Four examples of the Priest Rapids Dam 24-hour hydrograph under each of the proposed operational scenarios. Alternative one is a single peak each day during a week with projected mean daily discharge of 65 kcfs. Alternative two is two peaks each day during a week with projected mean daily discharge of 85 kcfs. Alternative three is two peaks each day during a week with projected mean daily discharge of 100 kcfs. Alternative four is traditional Reverse Load Factoring during a week with projected mean daily discharge of 105 kcfs.

4.5 Additional Pre-Spawn River Operation Testing

To further evaluate changes in discharge on fish movement and site fidelity, Grant PUD proposes to capture, tag, and release approximately 25 fish (of the 75 total fish) before the initiation of spawning (Lukas 2003). The initiation of spawning typically occurs before the third week of October. Beginning October 16th, increases in discharge to the daily peak will be stepped in one of three different flow differentials (40, 80, or 120 kcfs, Appendix A, October 16-21, 2006). Flows will be rapidly increased from the base flow to the selected differential. For example, if 40 kcfs is the selected differential and the base flow is 55 kcfs then discharged will be rapidly increased to 95 kcfs. Flows will be maintained at that level for one hour and then rapidly increased to the maximum daily peak. Differentials will be systematically tested for six days; however, current river

conditions may dictate which differential will be used. Depending upon results from the first six days, additional evaluations may occur later in the spawning period. The purpose of this experimental testing is to examine relationships between the magnitude of increasing discharge and changes in fish location on Vernita Bar. In addition to this particular experiment, these 25 tagged fish should provide additional tracking information throughout the remainder of the experiment as explained in Section 4.4. This test will be conducted regardless of how many fish are released from the previous day's tagging effort.

4.6 Fish Position

The fish position data (X and Y coordinates with associated date and time for each) collected from the hydroacoustic array tracks will be placed into one of five different Flow Event Categories which are: increasing peak flow, stable peak flow, decreasing peak flow, non-peak day flow, and non-peak night flow. The switch from day to night will be at the time of official sunset. The corresponding discharge from PRD and/or USGS will then be matched with the fish position coordinates to evaluate behavioral patterns. If possible, more precise discharge and/or velocity data will be modeled for these comparisons.

4.6.1 Relationship Between Fish Position and River Operational Alternatives During Base Flow

Using the acoustic tag tracking data, the relationship between fish position and River Operational Alternatives will be examined. The number of tagged fish present along the Vernita Bar (i.e., elevation intervals, 36-50, 50–55, 55–60, 60–65, and 65–70 kcfs, hereto referred as Elevation Intervals) will be recorded during non-peak flow periods. Chi-square tests of homogeneity will be used to compare spatial distributions using an R × C table of the form:

		River Operational Alternatives			
		#1	#2	#3	#4
Elevation Intervals	36-50				
	50-55				
	55-60				
	60-65				
	65-70				

4.6.2 Relationship Between Fish Position and Flow Peaks

For River Operational Alternatives 1, 2, and 3, one or two flow peaks will occur each day. Fish position will be compared during the Flow Event Categories to assess whether the change in river flow affected fish distributions at Vernita Bar. For any one peak flow condition, a test of homogeneity can be used to assess whether fish positions were distributed the same over the course of the event, using an R × C table of the form:

		Flow Event Categories				
		Increasing Peak Flow	**Peak Flow**	**Decreasing Peak Flow**	**Non-Peak Day Flow**	**Non-Peak Night Flow**
Elevation Intervals	36-50					
	50-55					
	55-60					

4.6.3 Relationship Between Change in Flow and Change in Fish Position

Using the acoustic tag tracking information, the change in fish position will be examined in relation to a change in flow over that time period. The null hypothesis is that there is no relationship between the direction of fish movement (i.e., fish moving towards or away from Vernita Bar) and change in flow (i.e., flows increasing or decreasing). To test the null hypothesis, a 2 × 2 contingency table test of homogeneity of the following form will be used :

	Flow Increase	**Flow Decrease**
Movement Away from Bar		
Movment Towards Bar		

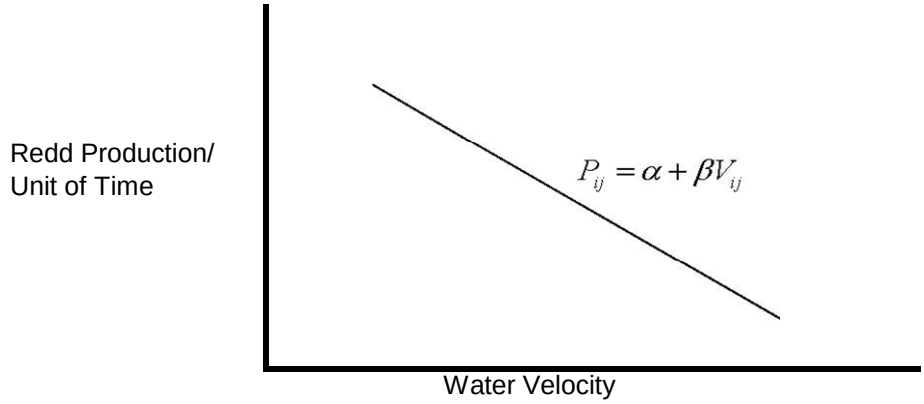
4.7 River Velocity

In an effort to better understand the relationship between river velocity and redd construction on Vernita Bar, previously modeled velocity data will be used. The objective is to record when specific redds are constructed so that a range of suitable discharge and velocity can be attributed to the timing of redd construction. At season's end, redd counts in each Elevation Interval will be

calculated. Using the velocity modeling data, a corresponding range of discharge and velocity will be placed with each redd within the five Elevations Intervals.

4.7.1 The Relationship Between Redd Production and Water Velocity

At each of the five Elevation Intervals, river velocity measurements will be calculated using a validated model. Redd surveys will be conducted daily throughout the spawning period to mark redds and determine the number of new redds constructed on a daily basis for each Elevation Interval. Redds will be marked by Grant PUD staff using GPS technology and/or physical marks from either boat or shore. Using the velocity model, all redds created above the base flow from one day to the next will have a range of velocity and corresponding flow assigned to the construction period. In addition to redd marking, the collection of corresponding tracking data from acoustic tags will be needed to strengthen the statistical analysis. To examine the relationship between redd production and water velocity, linear regression curves will be produced for each Elevation Interval in the following form:



5.0 Conclusion

The proposed study will mark the second consecutive year that Grant PUD has conducted a spawning experiment based on the Hanford Reach Agreement. Grant PUD has held several meetings with operators, agencies and tribes to discuss the results of the 2005 experiment. Many ideas and suggestions gathered at these meetings have been incorporated in the 2006 study proposal. The hypotheses to be tested are:

1. There is an increase in fish position movement (movement of fish positions determined by hydroacoustic tracking) during peak flow than fish position movement during non-peak flow.
2. Fish position on Vernita Bar is higher during peak flow than during non-peak flow.
3. There is an inverse relationship between increasing water velocity and redd production
4. The mean number of redds constructed above the 65 kcfs elevation in 2006 will be less than or equal to the mean number of redds constructed at the same elevation taken from all previous Vernita Bar redd surveys under RLF operation.

Some of the proposed statistical analyses will be subject to the collection of the appropriate data. If such data are not collected, then the results of such specific statistical tests will not be calculated. Great care will be used when defining the terms to be use and when determining the collection and placement of data for statistical testing. Finally, it is imperative that sufficient data is collected so that statistical tests can be performed that will lead to conclusions that will benefit overall management of fall Chinook salmon in the Hanford Reach.

6.0 Literature cited

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Vander Haegen, G.E., C.E. Ashbrook, K.W. Yi, and J.F. Dixon. 2004. Survival of spring Chinook salmon captured and released in a selective commercial fishery using gill nets and tangle nets. Fisheries Bulletin 68: 123-133.

Appendix A Hanford Reach Agreement Spawning Experiment 2006 Timeline

Date	Day	Activity	Daytime Flow
10/13/2006	Friday	Install and test acoustic array	50 kcfs
10/14/2006	Saturday	Install and test acoustic array	36 kcfs
10/15/2006	Sunday	Tag 25 fish-Vernita Bar count	36 kcfs
10/16/2006	Monday	Start flow regime, first block, first day	Base+flow differential, 40, 80, 120 kcfs
10/17/2006	Tuesday	First block, second day	Base+flow differential, 40, 80, 120 kcfs
10/18/2006	Wedneday	Second block, first day	Base+flow differential, 40, 80, 120 kcfs
10/19/2006	Thursday	Second block, second day	Base+flow differential, 40, 80, 120 kcfs
10/20/2006	Friday	Third block, first day	Base+flow differential, 40, 80, 120 kcfs
10/21/2006	Saturday	Third bock, second day	Base+flow differential, 40, 80, 120 kcfs
10/22/2006	Sunday	Tag fish, Vernita Bar count	36 kcfs
10/23/2006	Monday	Start of one or two peak discharge	Base flow + 1 or 2 spikes
10/24/2006	Tuesday	Continuing 1 or 2 peak discharge	Base flow + 1 or 2 spikes
10/25/2006	Wedneday	Continuing 1 or 2 peak discharge	Base flow + 1 or 2 spikes
10/26/2006	Thursday	Continuing 1 or 2 peak discharge	Base flow + 1 or 2 spikes
10/27/2006	Friday	Continuing 1 or 2 peak discharge	Base flow + 1 or 2 spikes
10/28/2006	Saturday	Continuing 1 or 2 peak discharge	Base flow + 1 or 2 spikes
10/29/2006	Sunday	Tag fish, Vernita Bar count	36 kcfs
10/30/2006	Monday	Continuing 1 or 2 peak discharge	Base flow + 1 or 2 spikes
10/31/2006	Tuesday	Continuing 1 or 2 peak discharge	Base flow + 1 or 2 spikes
11/1/2006	Wedneday	Continuing 1 or 2 peak discharge	Base flow + 1 or 2 spikes
11/2/2006	Thursday	Continuing 1 or 2 peak discharge	Base flow + 1 or 2 spikes
11/3/2006	Friday	Continuing 1 or 2 peak discharge	Base flow + 1 or 2 spikes
11/4/2006	Saturday	Continuing 1 or 2 peak discharge	Base flow + 1 or 2 spikes
11/5/2006	Sunday	Tag fish, Vernita Bar count	36 kcfs
11/6/2006	Monday	Continuing 1 or 2 peak discharge	Base flow + 1 or 2 spikes
11/7/2006	Tuesday	Continuing 1 or 2 peak discharge	Base flow + 1 or 2 spikes
11/8/2006	Wedneday	Continuing 1 or 2 peak discharge	Base flow + 1 or 2 spikes
11/9/2006	Thursday	Continuing 1 or 2 peak discharge	Base flow + 1 or 2 spikes
11/10/2006	Friday	Continuing 1 or 2 peak discharge	Base flow + 1 or 2 spikes
11/11/2006	Saturday	Continuing 1 or 2 peak discharge	Base flow + 1 or 2 spikes
11/12/2006	Sunday	Redd count, if needed	36 kcfs
11/13/2006	Monday	Continuing 1 or 2 peak discharge	Base flow + 1 or 2 spikes
11/14/2006	Tuesday	Continuing 1 or 2 peak discharge	Base flow + 1 or 2 spikes
11/15/2006	Wedneday	Continuing 1 or 2 peak discharge	Base flow + 1 or 2 spikes
11/16/2006	Thursday	Continuing 1 or 2 peak discharge	Base flow + 1 or 2 spikes
11/17/2006	Friday	Continuing 1 or 2 peak discharge	Base flow + 1 or 2 spikes
11/18/2006	Saturday	Continuing 1 or 2 peak discharge	Base flow + 1 or 2 spikes
11/19/2006	Sunday	Redd count, if needed	36 kcfs
11/20/2006	Monday	Continuing 1 or 2 peak discharge	Base flow + 1 or 2 spikes
11/21/2006	Tuesday	Remove hydroacoustic equipment	low flow
11/22/2006	Wedneday	Remove hydroacoustic equipment	low flow
11/26/2006	Sunday	Redd count, if needed	36 kcfs